

## LETTER

# Saving Tropical Forests by Knowing What We Consume

Xingli Giam<sup>1,2,\*</sup>, Letchumi Mani<sup>1,3,\*</sup>, Lian Pin Koh<sup>4</sup>, & Hugh T.W. Tan<sup>3</sup><sup>1</sup> Lee Kong Chian Natural History Museum, National University of Singapore, Singapore 117377, Singapore<sup>2</sup> School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98105, USA<sup>3</sup> Department of Biological Sciences, National University of Singapore, Singapore 117543, Singapore<sup>4</sup> School of Biological Sciences & The Environment Institute, The University of Adelaide, Adelaide, SA 5005, Australia**Keywords**

Certification; consumer attitudes; land-use change; oil palm; RSPO; sustainability labeling; Southeast Asia.

**Correspondence**

Xingli Giam, 1122 NE Boat St, School of Aquatic and Fishery Sciences, University of Washington, Seattle, WA 98105, USA.

Tel: +609-751-4871; fax: +206-685-7471.

E-mail: xgiam@uw.edu

**Received**

23 March 2015

**Accepted**

3 October 2015

\*These authors contributed equally to this work

**Editor**

Jonah Busch

doi: 10.1111/conl.12209

**Abstract**

Oil palm agriculture threatens tropical forests and biodiversity. Previous studies focused on finding ways to reduce the impacts of oil palm on biodiversity and the environment. However, the actual uptake of sustainable practices depends in part on economic demand. We undertook the first investigation on consumer attitudes and willingness-to-pay (WTP) for deforestation-free sustainable palm oil. In a sample of 251 consumers in Singapore, we found little consumer bias against palm oil per se. However, consumers had strong negative opinions toward products that cause deforestation. On average, consumers stated a WTP of 8.2–9.9% more for common palm oil-containing products that are deforestation-free. Given the current premium for segregated certified sustainable palm oil (CSPO; 1.5–5%), there is an incentive for manufacturers to use CSPO. Educational campaigns by environmental organizations and prominent advertising of CSPO usage through sustainability labels can potentially improve the economic demand for sustainable practices in oil palm agriculture.

**Introduction**

Globally, agricultural expansion is threatening forests and biodiversity. Forest conversion to oil palm monoculture negatively impacts biodiversity, carbon storage, and water quality in Southeast Asia—a global biodiversity hotspot (Wilcove *et al.* 2013; Carlson *et al.* 2014). These impacts will likely worsen as oil palm cultivation moves into other biodiversity-rich regions, e.g., the Neotropics (Lees & Vieira 2013) and Afrotropics (Wich *et al.* 2014).

This then raises the question: What policies can governments, conservation organizations, and growers pursue to minimize environmental impacts of oil palm cultivation? Researchers have demonstrated that certain strategies—maintaining forested riparian reserves and avoiding conversion of primary and secondary forests (Edwards *et al.* 2010; Giam *et al.* 2015)—can reduce biodiversity impacts of oil palm production. Increasing

numbers of growers, suppliers, and buyers (e.g., Wilmar, Cargill, Unilever, Nestlé, etc.) have committed to some of these strategies, in some cases, by following the sustainability standards set by the Roundtable for Sustainable Palm Oil (RSPO). Although RSPO standards should be made more stringent (Laurance *et al.* 2010) [e.g., protecting secondary forests against conversion (Giam *et al.* 2011), lowering areal thresholds for forest protection (Edwards *et al.* 2012)], RSPO-certified plantations are likely more sustainable than noncertified plantations with all else (e.g., preconversion conditions) being equal.

While these corporate commitments are undoubtedly influenced by the work of environmental groups through direct collaboration (e.g., Cargill and The Forest Trust; Cargill 2014) and pressure campaigns (e.g., Greenpeace campaigns against Unilever and Nestlé; The Economist 2010), the ultimate decision whether to adopt biodiversity-friendly strategies, when not legally

mandatory, likely hinges to some degree upon their economic benefits (Rotherham 2005). Because adopting sustainability standards incur nontrivial costs (Bateman *et al.* 2015), producers are more likely adopt them if: (1) consumer price premiums exist for products containing sustainable palm oil and/or (2) consumers have a negative opinion of unsustainable palm oil or a positive opinion of sustainable palm oil, possibly resulting in reputational damage and/or profit loss for corporations that do not adopt sustainability standards.

Although palm oil is used in many products from baked goods to cosmetics (Corley & Tinker 2003), explicitly labeling it in ingredient lists is not legally mandated in many jurisdictions (notable exceptions, however, include the United States and the European Union [Regulation 1169/2011]). Manufacturers may be unwilling to list palm oil because it has been linked with coronary heart disease (Chen *et al.* 2011) and environmental problems (Wilcove *et al.* 2013). For the same reasons, even manufacturers that use sustainable palm oil may not advertise it through certification labels. If consumers have no inherent bias against palm oil and prefer products containing sustainable palm oil over noncertified palm oil, omission of sustainability labels represents an opportunity lost to increase demand for more sustainable farming practices.

To date, there is little research on consumer knowledge, attitudes, and willingness-to-pay (WTP) for products containing sustainable palm oil. No study has examined the level of consumer knowledge of palm oil in common products and consumer attitudes toward sustainable palm oil, which may help inform product labeling policies and education campaigns to engender sustainable consumer behavior. Only one study has investigated WTP for sustainable palm oil (Bateman *et al.* 2010) where sustainability was framed in terms of tiger conservation. While Bateman *et al.*'s study was valuable in showing the effectiveness of using charismatic species in eliciting consumer-price premiums, it is also pertinent to evaluate WTP based on a zero-deforestation definition of sustainability given that a growing number of corporations such as McDonald's (McDonald's Corporation 2015) and Wilmar (Balch 2015) are committing to source or produce deforestation-free sustainable palm oil.

Here, we fill these knowledge gaps by surveying consumers in Singapore to answer the following questions: (1) Are consumers cognizant that certain products may contain palm oil? (2) Is there a consumer bias against products that contain palm oil? (3) Are consumers less likely to purchase these products if they cause deforestation? (4) Are consumers willing to pay more for common palm oil-containing products that are produced without deforestation? (5) What are the demographic correlates

of consumers' knowledge of palm oil in products and do demographic characteristics and the environmental worldview of consumers drive their WTP for products containing sustainable palm oil?

## Methods

### Survey location and administration

We used a hybrid face-to-face interview/self-administered questionnaire approach to obtain data from 251 respondents aged  $\geq 21$  years exiting 10 supermarkets in Singapore—a high-income city-state in Asia—from February–March 2012. Respondents were instructed to complete a standardized questionnaire in English (Appendix S1)—the language of instruction in Singapore; interviewers were present to clarify questions when required. Some respondents requested that questions be read aloud in English or translated to Malay, Mandarin, or Tamil—the other official languages in Singapore. The surveys were designed to minimize self-selection bias and to sample consumers from a variety of socioeconomic backgrounds (Appendix S1).

We chose this hybrid survey approach to sample the supermarket consumer population directly and to allow consumers to clarify questions with interviewers (Groves *et al.* 2009). Face-to-face surveys also have better response rates than mail, telephone, or Web surveys and are likely more representative of the population compared to Web surveys (Groves *et al.* 2009; Szolnoki & Hoffmann 2013). While the lack of publicly available consumer demographic data precluded formal evaluation of the actual sample representativeness, demographic characteristics of our sample generally reflect Singapore society (Table S1).

### Knowledge of palm oil in products

Some brands of these common products—chocolate bar, cookies, margarine, moisturizers, potato chips, and soap—are known to contain palm oil. We first asked respondents if they had purchased any of these products in the past year. A respondent who purchased  $\geq 1$  product(s) is henceforth referred to as a consumer. We asked consumers whether they thought some brands of products they had purchased may contain palm oil. Possible answers were: “yes,” “no,” and “not sure.”

### Assessing bias against palm oil

If a consumer did not think (or was unsure whether) some brands of a given product contained palm oil, we asked if he/she was more or less likely to buy the product if he/she knew that it contained palm oil. Possible

answers were: “much less likely,” “less likely,” “same as before,” “more likely,” and “much more likely.”

### Attitude toward products that cause deforestation

We asked consumers whether they were more or less likely to buy the product if it was made in an unsustainable manner. We explained that in our survey “unsustainable manner” meant forests had to be felled for cropland. We also asked consumers whether they were more or less likely to buy a sustainable (deforestation-free) alternative of each product, if available. Possible answers for both questions were: “much less likely,” “less likely,” “same as before,” “more likely,” and “much more likely.”

### WTP for sustainable palm oil

We quantified consumer WTP for products made with sustainable palm oil by asking whether he/she was likely to pay more for a deforestation-free product versus one whose sustainability was unclear or unknown. Possible answers were “yes” and “no.” For products that elicited a premium, we asked each consumer to state how much more they were willing to pay (in terms of percentage increase in price).

### Consumers’ environmental worldview

Using eight items from the New Ecological Paradigm scale (Dunlap *et al.* 2000), we identified two dimensions of a person’s environmental worldview (fundamental values underlying attitudes and beliefs): (1) cognizance-of-damage—the knowledge and concern about environmental damage and (2) anti-anthropocentrism/exemptionalism—the belief that humans do *not* have the right to dominate nature and that they are *not* immune from environmental damage (Appendix S2). Higher scores on these scales reflect a more proenvironment worldview.

### Statistical analysis

We tested whether consumers were less likely to purchase a given product after knowing that it causes deforestation (vs. simply containing palm oil) by performing a one-sided Monte Carlo test for paired differences (Appendix S3).

We examined whether: (1) demographic characteristics of consumers predicted knowledge of palm oil in products and (2) demographic characteristics and environmental worldview of consumers predicted WTP for products containing sustainable palm oil. For the first analysis, we analyzed binomial generalized linear mixed effect models (GLMMs) with logit link in a multimodel inferential framework (Burnham & Anderson 2002)

assuming a Bernoulli distribution for the binary response (knowledge of palm oil in products: yes—product contains palm oil vs. no/not sure). Candidate predictor variables were age, education level, gender, nationality, and product type. Consumer ID was fitted as a random intercept to account for repeated measures of knowledge across the six products.

In the second analysis, we modeled mean WTP (because individual product WTP differed little for most consumers) using two-step (“hurdle”) generalized linear models (GLMs). First, we modeled whether a consumer was willing (vs. not willing) to pay a premium using binomial logit link GLMs. Then, we modeled the mean WTP (log-transformed for normality) of consumers who were willing to pay a price premium using Gaussian GLMs. Candidate predictor variables were age, education level, gender, income, nationality, and scores on the cognizance-of-damage and anti-anthropocentrism/exemptionalism scales. Including income (the most frequently unreported variable) greatly reduced sample size from 227 to 151; we therefore repeated the analysis excluding income to identify other important predictors that may otherwise be obscured by the reduction in sample size.

We fitted models in a Bayesian framework in which model inferences do not require large-sample assumptions (Kéry 2010). We used Widely Applicable Information Criterion (Watanabe 2010) to evaluate relative model support. To quantify model goodness-of-fit, we calculated proportion of variance explained by fixed effects ( $R^2_m$  for GLMMs and  $R^2$  for GLMs). Models were fitted using JAGS 3.4.0 (Plummer 2013) in R (R Core Team 2014; Appendix S4).

## Results

### Knowledge of palm oil in products

Of the 251 consumers surveyed, 221, 201, 194, 178, 150, and 136 had purchased cookies, soaps, chocolate bars, potato chips, moisturizers, and margarine, respectively, in the previous year (Table 1). Between 48% (chocolate bar) and 75% (soap) of consumers correctly indicated that some brands of these products contain palm oil (Table 1). The best supported model ( $R^2_m = 0.14$ ,  $n = 1,019$  observations across 237 consumers) indicated that older, tertiary (or higher)-educated, male, and non-Singaporean consumers were, on average, more cognizant that some brands of a given product may contain palm oil (Tables 2 and S2).

### Bias against palm oil

Among consumers who did not know or were unsure whether some brands of a given product contained palm

**Table 1** Summary of survey responses

Product <sup>a</sup>	Resp <sup>b</sup>	Cons <sup>c</sup>	Know (%) <sup>d</sup>	PO (%) <sup>e</sup>	UNS_PO (%) <sup>g</sup>	SUS_PO (%) <sup>h</sup>	WTP (%) <sup>i</sup>	mWTP (%) <sup>j</sup>
Choc	251	194	94 (48%)	33 (33%)	70 (70%)	166 (86%)	143 (74%)	9.9
Cookies	251	221	122 (55%)	26 (26%)	69 (70%)	184 (83%)	155 (70%)	9.2
Marg	251	136	92 (68%)	9 (20%)	25 (57%)	118 (87%)	94 (69%)	8.2
Mois	251	150	83 (55%)	20 (30%)	35 (52%)	129 (86%)	108 (72%)	9.9
Pota	251	178	89 (50%)	21 (24%)	55 (62%)	150 (84%)	129 (72%)	9.3
Soap	251	201	151 (75%)	10 (20%)	26 (52%)	176 (88%)	146 (73%)	9.5

<sup>a</sup>Products are: Choc (chocolate bar); Cookies (cookies); Marg (margarine); Mois (moisturizers); Pota (potato chips); Soap (soap).

<sup>b</sup>Resp: Number of respondents.

<sup>c</sup>Cons: Number of consumers (i.e., respondents who bought the product in the past year).

<sup>d</sup>Know: Number (and %) of consumers who answered (correctly) that some brands of the product contain palm oil.

<sup>e</sup>PO: Of the consumers did not think (or was unsure whether) some brands of the product contain palm oil, the number (and %) who answered they were “much less likely” or “less likely” to purchase the product if they knew it contained palm oil.

<sup>f</sup>UNS\_PO: Of the consumers did not think (or was unsure whether) a given product contains palm oil, the number (and %) who answered they were “much less likely” or “less likely” to purchase the product if they knew it causes deforestation.

<sup>g</sup>SUS\_PO: Of all consumers, the number (and %) who answered they were “more likely” or “much more likely” to purchase the sustainable (deforestation-free) alternative of a given product.

<sup>h</sup>WTP: Of all consumers, the number (and %) who answered they were willing to pay a price premium to purchase the sustainable (deforestation-free) alternative of a given product.

<sup>i</sup>mWTP: The mean price premium (including consumers who indicated a price premium of zero) for the sustainable (deforestation-free) alternative of a given product.

**Table 2** Model coefficients (and 95% credible intervals [CI]) and associated inferences from the best supported GLMM predicting knowledge of palm oil in products ( $n = 1,019$  from 237 consumers)

Parameters	Coefficients (95% CI)	Inference
Product		Soap was the product most frequently identified as containing palm oil, followed by margarine, moisturizers, cookies, potato chips, and chocolate bar.
Chocolate bar	-1.72 (-2.28--1.16)	
Cookies	-1.36 (-1.90--0.83)	
Margarine	-0.24 (-0.85--0.38)	
Moisturizers	-1.30 (-1.89--0.71)	
Potato Chips	-1.57 (-2.16--1.01)	
Age	0.33 (0.03--0.65)	Older consumers likely to have greater knowledge of palm oil in products.
Education		Consumers with tertiary (or higher) education likely to have greater knowledge of palm oil in products.
Tertiary or higher	1.34 (0.67--2.04)	
Gender		Male consumers likely to have greater knowledge of palm oil in products.
Male	0.51 (-0.04--1.07)	
Nationality		Non-Singaporean consumers likely to have greater knowledge of palm oil in products.
Non-Singaporean	0.58 (-0.06--1.24)	

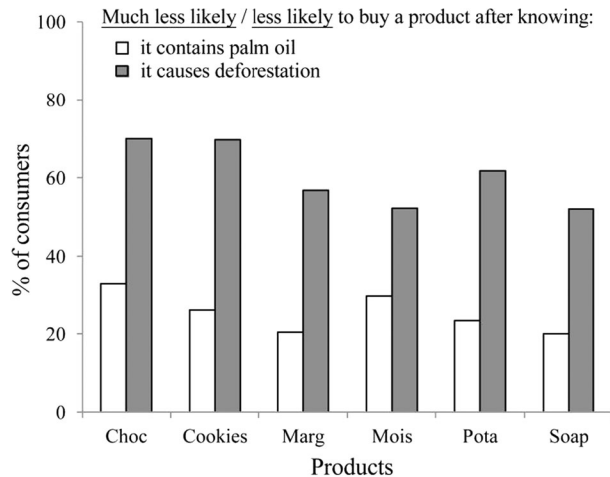
oil, a minority indicated that they were “less likely” or “much less likely” to purchase it if they knew it contained palm oil (between 20% [soap] and 33% [chocolate] of consumers; Figure 1; Table 1).

### Attitude toward products that cause deforestation

When told that forests had to be cleared to make the product, consumers became less likely to buy a product as compared to when they were told the product

contained palm oil (without any indication of sustainability; Monte Carlo test for paired differences  $P < 0.002$  for all products; Figure 1).

Overall, between 52% (soap) and 70% (chocolate bar) of consumers said that they were “less likely” or “much less likely” to buy a product if it was unsustainably produced (Figure 1). Conversely, a large majority of consumers (between 83% and 88%) said they were “more likely” or “much more likely” to buy the sustainable alternative, if available (Table 1).



**Figure 1** Percentage of consumers who replied they were “much less likely” or “less likely” to buy a product after knowing it contains palm oil (i.e., with no information on sustainability) versus knowing it causes deforestation.

A Monte Carlo test for differences (Appendix S3) indicated that consumers were less likely to buy a product if they know it causes deforestation ( $P < 0.002$  for all products). Products are: Choc (chocolate bar); Cookies (cookies); Marg (margarine); Mois (moisturizers); Pota (potato chips); Soap (soap).

### WTP for sustainable palm oil

The majority of consumers stated that they were willing to pay a price premium for the sustainable (deforestation-free) product over one whose sustainability is unknown (Table 1). The best model indicated that higher-income consumers were more willing to pay a premium ( $R^2 = 0.06$ ,  $n = 151$ ; Tables 3 and S3). When income was excluded from the predictor set, the best model suggested that more highly educated and female consumers were more willing to pay a premium ( $R^2 = 0.05$ ,  $n = 227$ ; Tables 3 and S4).

On average, consumers stated that they were willing to pay a price premium between 8.2% (margarine) and 9.9% (moisturizers; Table 1). Only education level was included in the best model predicting the magnitude of price premium: those with at least tertiary education indicated a greater WTP ( $R^2 = 0.08$ ,  $n = 113$ ; Tables 3 and S5); excluding income from the analysis yielded the same best model ( $R^2 = 0.05$ ,  $n = 163$ ; Tables 3 and S6).

### Discussion

Many consumers were unaware that some brands of products they had bought in the past year may contain palm oil (hereafter, unaware consumers). Consumers with tertiary (or higher) education were more aware that some brands of products may contain palm oil pos-

sibly because a higher level of education facilitates a consumer’s search for (Katona & Mueller 1955) and understanding of information. Older consumers may have greater awareness of palm oil as an ingredient because of knowledge accumulation with age and/or a greater interest in food ingredients owing to health concerns (Drichoutis *et al.* 2005). Interestingly, males were more knowledgeable about palm oil in products. It is possible that men were more likely to use ingredient information on food labels than women (Drichoutis *et al.* 2005). Last, Singaporeans had a poorer awareness of palm oil in products than non-Singaporeans possibly because whereas palm oil consumption is a global environmental issue, environmental education and campaigns aimed toward the local populace centers on issues pertinent to Singapore, e.g., air pollution, waste disposal, and local nature conservation (Wong & Stimpson 2004; Hobson 2006). Indeed, it was only after environmental impacts of palm oil were felt locally—haze caused by peat fires on oil palm concessions in neighboring Sumatra in 2013—that a palm oil awareness campaign was organized in Singapore (The Online Citizen 2015; <http://web.breathewhatwebuy.com>).

While there was little bias against palm oil per se, consumers had a strong negative opinion toward products that cause deforestation. A large majority of both unaware and aware consumers indicated they were more likely to buy an alternative deforestation-free product if available. Our results demonstrated that consumers in Singapore, like consumers in France (Disdier *et al.* 2013), were generally concerned about the link between agriculture and deforestation. Given that consumers showed little bias against palm oil and preferred deforestation-free products, there is an incentive for manufacturers to use sustainable palm oil and advertise their usage in the media or through food labels.

Most consumers were willing to pay a price premium for products containing *sustainable* palm oil. Higher-income consumers ( $\geq$ SGD4,500/month) were more willing to pay a price premium likely owing to greater financial ability; this effect was also observed for sustainable wood products (Aguilar & Vlosky 2007). More highly educated and female consumers were more likely to pay a price premium; this was consistent with previous studies on various green products, e.g., carbon-efficient cars (Achtmeit 2012). Environmental concern tends to be greater in women (Manieri *et al.* 1997) and this may translate to proenvironment buying attitudes and behaviors (Manieri *et al.* 1997; Grunert *et al.* 2014). Similarly, highly educated consumers tend to be more willing to contribute to environmental conservation efforts (e.g., agreeing to a tax increase for greater environmental protection; Torgler & García-Valiñas 2007). Among consumers who were willing to pay a premium, only



**Table 3** Model coefficients (and 95% CI) from the best supported GLMs predicting consumer WTP for common palm oil-containing products that are deforestation-free

Parameters	Coefficients (95% CI)	Inference
Income included in the candidate predictor set		
Step 1. Willing versus not willing to pay a price premium ( $n = 151$ )		
Income (SGD/month)		Consumers with an income $\geq$ SGD\$4,500/month were most likely to state a nonzero WTP.
1,500–4,499	0.14 (–0.68–0.96)	
$\geq 4,500$	1.14 (0.05–2.36)	
Step 2. Magnitude of WTP among consumers who were willing to pay a premium ( $n = 113$ )		
Education		Consumers with tertiary education stated a higher WTP.
Tertiary or higher	0.49 (0.18–0.81)	
Income excluded from the candidate predictor set		
Step 1. Willing versus not willing to pay a price premium ( $n = 227$ )		
Education		Consumers with tertiary (or higher) education were more likely to state a nonzero WTP.
Tertiary or higher	0.68 (0.06–1.31)	
Gender		Female consumers were more likely to state a nonzero WTP.
Male	–0.65 (–1.26––0.05)	
Step 2. Magnitude of WTP among consumers who were willing to pay a premium ( $n = 163$ )		
Education		Consumers with tertiary education stated a higher WTP.
Tertiary or higher	0.33 (0.10–0.57)	

SGD: Singapore Dollar (1SGD  $\sim$  0.8USD in February–March 2012).

education level was correlated with the magnitude of premium.

Manufacturers have an economic incentive to use certified sustainable palm oil (CSPO) considering that the consumer premium (8.2–9.9%) exceeds the average premium paid to growers for segregated CSPO (1.5–5%; WWF 2012). If consumer premium levels also apply to products that do not contain CSPO but support its production, the premium margin is even greater; growers' price premium through the RSPO GreenPalm book-and-claim program is currently  $\sim$ 0.3% (March 2014–February 2015; [www.indexmundi.com](http://www.indexmundi.com), [www.greenpalm.org](http://www.greenpalm.org)). An important caveat is that consumers may overstate their WTP by about 35% (median)–100% (70<sup>th</sup> percentile; Murphy *et al.* 2005). However, based on these values, actual consumer premiums are still likely to at least match the premiums paid to growers for segregated CSPO.

Our research suggests that to generate greater consumer demand for CSPO, one step might be to increase public awareness of products containing palm oil and the environmental issues related to oil palm cultivation. Public information/outreach campaigns by nongovernmental environmental should aim to explain how sustainability

certification aids in biodiversity conservation along with its shortcomings to allow consumers to make an informed purchasing decision. Manufacturers should also advertise their usage of CSPO through sustainability labels and marketing campaigns. The low model  $R^2$  values suggest that such campaigns should adopt a measured approach in targeting consumers: while some emphasis on certain consumer groups (those who tend to be less knowledgeable about palm oil and those who are less likely to pay a premium for sustainably produced products as revealed by our models) might be worthwhile, education campaigns should ultimately be broad enough to target all consumers.

An obvious limitation of our study is the narrow geographical scope. Unlike other developed world countries, Singapore has an authoritarian government and a more politically apathetic populace (Mutalib 2000), but like these countries, environmental activism is allowed albeit somewhat muted possibly owing to political apathy. We therefore expect attitudes and WTP among Singapore consumers to be similar to or slightly less pro-CSPO than developed world consumers. Because cultures are generally heterogeneous between (and within) countries, large multicountry studies are required to truly

elucidate the range of attitudes and WTP in consumers globally. It is important that these studies incorporate developing world consumers who use palm oil as a staple product (e.g., for cooking) for whom there are no data.

Our results suggest informing consumers about the sustainability of a product can potentially create the economic demand for sustainable practices in oil palm agriculture. Our study and Bateman *et al.* (2010) are the first to reveal WTP for sustainable palm oil. Having confirmed that consumer support and price premiums for deforestation-free sustainable palm oil exist, the onus is now on RSPO member growers and manufacturers to ensure that CSPO is truly deforestation-free by mandating that *all* forests (including logged and secondary forests) above a certain areal threshold (e.g., 10 km<sup>2</sup>; Edwards *et al.* 2012) are off limits for conversion.

## Acknowledgments

Data collection was supported by an Undergraduate Research Opportunities Programme grant to LM from Department of Biological Sciences, National University of Singapore. LPK was supported by the Australian Research Council. XG thanks JD Olden for research and financial support. We thank DS Wilcove for his feedback on the study design and helpful comments on the manuscript, and LR Carrasco for useful discussions. This research was approved by the Institutional Review Board of the National University of Singapore (12-050). XG designed research with LPK, LM, and HTW. LM conducted surveys. XG analyzed data and led writing of manuscript; all authors contributed to the final manuscript.

## Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's web site:

**Appendix S1.** Additional survey details and standardized questionnaire.

**Appendix S2.** Factor analysis of pro-environment worldview.

**Appendix S3.** Monte-Carlo test for paired differences.

**Appendix S4.** Bayesian model priors and settings.

**Table S1.** Demographic characteristics of respondents vs. total and resident population in Singapore in 2013–2014.

**Table S2.** Ten best-supported models predicting knowledge of palm oil in products.

**Table S3.** Ten best-supported models predicting willingness-to-pay (binary: yes/no) in the analysis that included income as a candidate predictor variable.

**Table S4.** Ten best-supported models predicting willingness-to-pay (binary: yes/no) in the analysis that excluded income as a candidate predictor variable.

**Table S5.** Ten best-supported models predicting magnitude of price premium in the analysis that included income as a candidate predictor variable.

**Table S6.** Ten best-supported models predicting magnitude of price premium in the analysis that excluded income as a candidate predictor variable.

## References

- Achtnicht, M. (2012). German car buyers' willingness to pay to reduce CO<sub>2</sub> emissions. *Climatic Change*, **113**, 679–697.
- Aguilar, F.X. & Vlosky, R.P. (2007). Consumer willingness to pay price premiums for environmentally certified wood products in the U.S. *Forest Policy Econ.*, **9**, 1100–1112.
- Balch, O. (2015). World's largest palm oil trader commits to zero deforestation. <http://www.theguardian.com/sustainable-business/2015/jan/26/palm-oil-companies-deliver-deforestation-promises> (visited Jul. 23, 2015).
- Bateman, I.J., Fisher, B., Fitzherbert, E., Glew, D. & Naidoo, R. (2010). Tigers, markets and palm oil: market potential for conservation. *Oryx*, **44**, 230–234.
- Bateman, I.J., Coombes, E., Fitzherbert, E., *et al.* (2015). Conserving tropical biodiversity via market forces and spatial targeting. *Proc. Natl. Acad. Sci. USA*, **112**, 7408–7413.
- Burnham, K.P. & Anderson, D.R. (2002). *Model selection and multimodel inference: a practical information-theoretic approach*. Springer, New York.
- Cargill. (2014). Cargill and TFT join hands to advance sustainability. <http://www.cargill.com/news/releases/2014/NA31686457.jsp/> (visited Jul. 2015).
- Carlson, K.M., Curran, L.M., Ponette-González, A.G., *et al.* (2014). Influence of watershed-climate interactions on stream temperature, sediment yield, and metabolism along a land use intensity gradient in Indonesian Borneo. *J. Geophys. Res.: Biogeosci.*, **119**, 1110–1128.
- Chen, B.K., Seligman, B., Farquhar, J.W. & Goldhaber-Fiebert, J.D. (2011). Multi-country analysis of palm oil consumption and cardiovascular disease mortality for countries at different stages of economic development: 1980–1997. *Glob. Health*, **7**, 45. doi:10.1186/1744-8603-7-45
- Corley, R.H.V. & Tinker, P.B.H. (2003). *The oil palm. 4th edition*. Blackwell, Oxford, UK.
- Disdier, A.-C., Marette, S. & Millet, G. (2013). Are consumers concerned about palm oil? Evidence from a lab experiment. *Food Policy*, **43**, 180–189.
- Drichoutis, A.C., Lazaridis, P. & Nayga, Jr R.M. (2005). Nutritional knowledge and consumer use of nutritional food labels. *Eur. Rev. Agric. Econ.*, **32**, 93–118.
- Dunlap, R.E., Van Liere, K.D., Mertig, A.G. & Jones, R.E. (2000). Measuring endorsement of the new ecological paradigm: a revised NEP scale. *J. Soc. Issues*, **56**, 425–442.

- Edwards, D.P., Hodgson, J., Hamer, K.C., *et al.* (2010). Wildlife-friendly oil palm plantations fail to protect biodiversity effectively. *Conserv. Lett.*, **3**, 236-242.
- Edwards, D.P., Fisher, B. & Wilcove, D.S. (2012). High conservation value or high confusion value? Sustainable agriculture and biodiversity conservation in the tropics. *Conserv. Lett.*, **5**, 20-27.
- Giam, X., Clements, G.R., Aziz, S.A., Chong, K.Y. & Miettinen, J. (2011). Rethinking the 'back to wilderness' concept for Sundaland's forests. *Biol. Conserv.*, **144**, 3149-3152.
- Giam, X., Hadiaty, R.K., Tan, H.H., *et al.* (2015). Mitigating the impact of oil-palm monoculture on freshwater fishes in Southeast Asia. *Conserv. Biol.*, doi:10.1111/cobi12483
- Groves, R.M., Fowler, Jr F.J., Couper, M.P., Lepkowski, J.M., Singer, E. & Tourangeau, R. (2009). *Survey methodology, 2nd edition*. John Wiley & Sons, Hoboken.
- Grunert, K., Hieke, S. & Wills, J. (2014). Sustainability labels on food products: consumer motivation, understanding and use. *Food Policy*, **44**, 177-189.
- Hobson, K. (2006). Enacting environmental justice in Singapore: performative justice and the Green Volunteer Network. *Geoforum*, **37**, 671-681.
- Katona, G.C. & Mueller, E. (1955). A study of purchase decisions. Pages 30-87 in L.H. Clark, editor. *Consumer behavior: the dynamics of consumer reactions*. New York University Press, New York.
- Kéry, M. (2010). *Introduction to WinBUGS for ecologists*. Academic Press, Burlington.
- Laurance, W.F., Koh, L.P., Butler, R., *et al.* (2010). Improving the performance of the Roundtable on sustainable palm oil for nature conservation. *Conserv. Biol.*, **24**, 377-381.
- Lees, A.C. & Vieira, I.C. (2013). Forests: oil palm concerns in Brazilian Amazon. *Nature*, **497**, 188.
- Manieri, T., Barnett, E.G., Valdero, T.R., Unipan, J.B. & Oskamp, S. (1997). Green buying: the influence of environmental concern on consumer behavior. *J. Soc. Psychol.*, **137**, 189-204.
- McDonald's Corporation. (2015). *McDonald's corporation commitment on deforestation*. [http://www.aboutmcdonalds.com/content/dam/AboutMcDonalds/2.0/pdfs/Commitment on Deforestation.pdf](http://www.aboutmcdonalds.com/content/dam/AboutMcDonalds/2.0/pdfs/Commitment%20on%20Deforestation.pdf) (visited Jul. 23, 2015).
- Murphy, J.J., Allen, P.G., Stevens, T.H. & Weatherhead, D. (2005). A meta-analysis of hypothetical bias in stated preference valuation. *Environ. Resour. Econ.*, **30**, 313-325.
- Mutalib, H. (2000). Illiberal democracy and the future of opposition in Singapore. *Third World Q.*, **21**, 313-342.
- Plummer, M. (2013). Just another Gibbs sampler (JAGS) v. 3.4.0. <http://sourceforge.net/projects/mcmc-jags/> (visited Feb. 2, 2015).
- R Core Team. (2014). *R: a language and environment for statistical computing v. 3.1.2*. R Foundation for Statistical Computing, Vienna, Austria. <http://www.R-project.org> (visited Feb. 2, 2015).
- Rotherham, T. (2005). *The trade and environmental effects of ecolabels: assessment and response*. United Nations Environment Programme. <http://www.unep.ch/etb/publications/Ecolabelpap141005f.pdf> (visited Jul. 23, 2015).
- Szolnoki, G. & Hoffmann, D. (2013). Online, face-to-face and telephone surveys—comparing different sampling methods in wine consumer research. *Wine Econ. Pol.*, **12**, 57-66.
- The Economist. (2010). The campaign against palm oil: the other oil spill. <http://www.economist.com/node/16423833> (visited Jul. 23, 2015).
- The Online Citizen. (2015). "We Breathe What We Buy," a campaign to combat Singapore's annual haze problem. <http://www.theonlinecitizen.com/2015/07/we-breathe-what-we-buy-a-campaign-to-combat-singapores-annual-haze-problem/> (visited Jul. 23, 2015).
- Torgler, B. & García-Valiñas, M.A. (2007). The determinants of individuals' attitudes towards preventing environmental damage. *Ecol. Econ.*, **63**, 536-552.
- Watanabe, S. (2010). Asymptotic equivalence of Bayes cross validation and widely applicable information criterion in singular learning theory. *J. Mach. Learn. Res.*, **11**, 3571-3594.
- Wich, S.A., Garcia-Ulloa, J., Kuhl, H.S., Humle, T., Lee, J.S.H. & Koh, L.P. (2014). Will oil palm's homecoming spell doom for Africa's great apes. *Curr. Biol.*, **24**, 1-5.
- Wilcove, D.S., Giam, X., Edwards, D.P., Fisher, B. & Koh, L.P. (2013). Navjot's nightmare revisited: logging, agriculture, and biodiversity in Southeast Asia. *Trends Ecol. Evol.*, **28**, 531-540.
- Wong, F.B.K. & Stimpson, P.G. (2004). Environmental education in Singapore: a curriculum for the environment or in the national interest. *Int. Res. Geo. Environ. Educ.*, **12**, 123-128.
- WWF. (2012). Profitability and sustainability in palm oil production. WWF report March 2012. <http://wwf.panda.org/?204548/Profitability-and-Sustainability-in-Palm-Oil-Production> (visited Jul. 23, 2015).